



Fig. 2.36 Rotation of fluid about a vertical axis.

uniform rotation about a vertical axis

Rotation of a fluid, moving as a solid, about an axis is called *forced-vortex* motion. Every particle of fluid has the same angular velocity. This motion is to be distinguished from *free-vortex* motion, where each particle moves in a circular path with a speed varying inversely as the distance from the center. Free-vortex motion is discussed in Chaps. 7 and 9. A liquid in a container, when rotated about a vertical axis at constant angular velocity, moves as a solid after some time interval. No shear stresses exist in the liquid and the only acceleration that occurs is directed radially inward toward the axis of rotation. The equation of motion in the vertical direction on a free body shows that hydrostatic conditions prevail along any vertical line; hence, the pressure at any point in the liquid is given by the product of specific weight and vertical distance from the free surface. In equation form, Fig. 2.36,

$$\frac{\partial p}{\partial y} = -\gamma$$

In the equation of motion tangent to the circular path of a particle, the acceleration is zero, and the pressure does not change along the path.

In the equation of motion in the radial (horizontal) direction (Fig. 2.36), with a free body of length δr and cross-sectional area δA , if the pressure at r be p , then, at the opposite face, the pressure is $p + (\partial p / \partial r) \delta r$. The acceleration is $-\omega^2 r$; hence

$$p \delta A - \left(p + \frac{\partial p}{\partial r} \delta r \right) \delta A = \frac{\delta A \delta r \gamma}{g} (-\omega^2 r)$$